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USING ARCHETYPES TO CREATE USER PANELS FOR USABILITY STUDIES

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Keywords: comfort, anthropometry, ergonomics, archetypes

1. Introduction

Design engineers who are involved in the early conceptual phase of the development of products such as seats, headphones and domestic appliances stress the increasing importance of comfort. Comfort is taken into account in the purchasing decisions of buying a chair, a bed, and when driving a car, or flying. Industry strives to produce products that are comfortable in order to stay ahead of competition. The Second European Survey on Working Conditions [Merllie, *et al.* 2002] that took place in 1996, where a sample of 1000 workers from each member state were interviewed, revealed that back pain (30% of the workers) and muscular pains in arms or legs (17% of workers) were amongst the most common work-related health problems. Absenteeism due to work-related health problems affects 23% of workers each year (averaging out at 4 working days lost per worker). These health problems strongly relate to postural musculoskeletal discomfort. Hence, designers need to increase their knowledge on both comfort and discomfort in product design (and workspaces).

The terms *comfort* and *discomfort* are widely used in studies where prototypes are tested for usability. Despite the frequent use of these terms there is an absence of a general notion of comfort or discomfort. There are three main issues when designing a product to achieve comfort: 1) the exact cause of comfort is unknown, 2) comfort relies to a certain extent on subjectivity and, 3) there is a lack of a methodology for considering comfort in the design process [Vink 2005]. Extensive research mostly in the form of comfort studies [Kuijt-Evers 2004 ; DeLooze, *et al.* 2003] has explored some of the influential factors of comfort such as postural stress [Kee, *et al.* 2012], levels of pressure and force increase [Goossens, *et al.*, 2002] and noise [Vink, *et al.* 2001], most of which are physical, physiological or linked to external attributes of the environment in which the interaction between a human and a product takes place. For products that are in a physical contact with the human body, such as chairs and hand tools, researchers have attempted to match product dimensions with people's anthropometry [Mououdi, *et al.* 1997 ; Cho 1994]. However, research is limited in attempting to match external ear products, such as headphones and headsets with human ear dimensions, partially due to the limited data sets available. In terms of methodology, research is scarce regarding the evaluation of the ergonomic functionality of products.This translates into two issues: primarily current comfort studies benchmark the prototypes against user panels which are not representative of the population as a whole; and secondly there is a lack of methodology to define product dimensions and predict good fit.

The aim of this paper is to provide a methodology to develop a reliable user panel for the execution of comfort studies in the ear industry, hence allowing qualitative data to be captured whilst reducing the size of the user panel, and substantially reducing costs. By using an example of an early headset prototype this paper also provides a methodological framework for the design of a comfort study. Additionally a study that was carried out to test the validity of the proposed framework is also presented. Essentially this research responds to the call for a new approach towards comfort and draws inspiration from Vink [2012] who has stressed the need for an improved comfort methodology. The findings of this research are expected to assist designers in developing successful products in terms of physical comfort and functionality. The paper consists of four parts: 1) First it reviews the existing literature on definitions of comfort and the studies attempting to link comfort to anthropometry; 2) Then it presents the research methodology and the analysis of the data used for this study. 3) The findings from these studies are presented. 4) The paper concludes with a discussion of theoretical and industrial implications, the limitations and the contributions of the studies presented in this paper.

2. Literature Review

2.1 The concept of comfort

This section will introduce comfort definitions. In dictionaries comfort is described as "a subjective state of well-being in relation to an induced environment including mechanical vibration or shock". Comfort is, however, commonly associated with terms such as, "assistance, relief, support" and is also seen as "a feeling of freedom from worry or disappointment" [The Oxford Dictionary of English 2005]. Slater [1987] defines comfort as a pleasant state of physiological, psychological and physical harmony between a human being and the environment. Richards [1980] states that comfort is the state of a person that involves a sense of subjective well-being in reaction to an environment or a situation. In regards to the subjective nature of comfort Vink [2005] states that comfort is a subjective experience. For a passenger on a long distance flight, back discomfort is of great importance whereas another passenger wants a reduction in noise or more space. Comfort is defined as (1) a construct of subjectively defined by one's personal nature, (2) as a reaction to the environment and (3) is affected by factors of various natures (physical, psychological and physiological). The focus of this paper is on the physical properties of comfort.

2.2 A debate in the literature: comfort versus discomfort

2.2.1. Comfort and discomfort as points in a continuum scale

Comfort has been linked to the term "discomfort" since the first attempt to operationally define comfort as "the absence of discomfort" [Hertzberg 1958]. Comfort is not a well-defined concept yielding an on-going debate in the literature. The debate stresses the difference between comfort and discomfort. Several researchers [Hertzberg 1958 ; Richards 1980 ; Bishu, *et al.* 1981] seem to be making a distinction between two different states of comfort. According to Bishu *et al.* [1981], in particular for seating design, "the goal of the designers is to reach the state of absence of discomfort, where the working individual is oblivious of the fact that he or she is seated." In his study, Richards [1980] has suggested that the fact that people rate their subjective responses across the entire continuum from discomfort to comfort indicates that comfort is part of a bipolar dimension that can be attributed to characteristics of design. This statement is supported by a number of papers in hand tool evaluation studies in which comfort is measured in terms of discomfort [Chao, *et al.* 2000], [Fellows, *et al.* 1991]. In hand tools comfort is mainly determined by functionality and the physical interaction between the user and the product. As discomfort factors are present in hand tool use, comfort may be dominated by discomfort [Kuijt – Evers, *et al.* 2004]. In their study, Kuijt-Evers *et al.* [2004] identidied factors having the closest relationship to comfort among 40 descriptors, such as good fit in hand, functional, easy to use, reliable, etc. These factors were clustered. The statistical analysis distinguished 6 comfort factors: functionality, posture and muscles, irritation and pain of hand and fingers, irritation of hand surface, handle characteristics and aesthetics. These factors explain 53.8 % of the variance. In the use of hand tools the same descriptors relate to both comfort and discomfort.

Two studies in the design of seats support the above statement: [Jianghong, *et al.* 1994] for the passenger seat for a new type of bus and [Wilder, *et al.* 1994] to compare two different track seats (with and without suspension) when changing driving postures. It was concluded that comfort and discomfort can be seen as two opposites on a continuous scale. This stems from the fact, that people frequently and naturally distinguish ordered levels of their subjective responses across the entire continuum from strongly positive to strongly negative [Richards 1980]. The same principle underlies the graded scales [Habsburg, *et al.* 1977] that have been used to evaluate seats.

2.2.2. A division of discontinuity between comfort and discomfort

Opposing to the theory of seeing comfort and discomfort as two extreme states on a continuous scale ranging from extreme discomfort through a neutral state to extreme comfort, several studies have questioned the intuitive assumption of comfort/ discomfort as a single dimension on a continuous scale. These studies [Kleeman 1981 ; Zhang, *et al.* 1996], argue that comfort and discomfort are affected by distinctly different variables, and assessment of comfort and discomfort should hence be based on different types of criteria. In the study by Zhang *et al.* [1996], the identification of these variables was the primary goal. A total 104 respondents provided descriptors of the feelings they experienced when they felt comfortable (e.g. agreeable, at ease, calm) or uncomfortable (e.g. fatigue, cramped, restless) in a seated workplace. From this study, 43 descriptors emerged which were grouped into two main factors, which were interpreted as comfort and discomfort. Feelings of discomfort are mainly associated with pain, tiredness, soreness and numbness. Comfort, on the other hand, is associated with feelings of relaxation and well-being [Paul, *et al.* 1997]. The theory of Helander and Zhang [1996] convinced the authors of this paper that there was a division or discontinuity between comfort and discomfort scales. It was concluded that siting comfort and discomfort were identified as independent entities associated with different factors: discomfort is related to biomechanics and fatigue factors, whereas comfort is related to a sense of well-being and aesthetics. Comfort and discomfort need to be treated as different and complementary entities in ergonomic investigations.

2.3 Anthropomentry and comfort: the challenge of fitting the tasks to the human

A challenge for design engineers and comfort specialists who work at the early stages of the development of products that are in physical contact with the human body is to define a set of human factors in order to achieve high physical comfort. Defining these factors will enable designers to predict physical factors of comfort such as *good fit* in the ear (in the case of wearing a Bluetooth device). Anthropometry is considered the very ergonomic core of any attempt to resolve the dilemma of fitting the tasks to the human [Sanders and McCormick 1993]. In regards to external ear products such as bluetooth headsets and headphones good fit is a crucial physical factor of comfort to ensure the success of these products. Designers require anthropometric data to identify human factors and inform design decisions with respect to external ear devices. Current approaches are restricted in the presentation of of anthropometric data only. The collection of ear data includes the use of various measurement instruments. Jung and Jung [2001] provided anthropometric dimensions of ears of Korean subjects using digital calipers. Other methods suggest the use of simple geometric calculations to acquire dimensions from a 2D photograph by setting reference points before taking the photographs. In regards to data collection of other body parts, such as head and legs data other relatively noninvasive, 3D imaging techniques are applied. These include various forms of stereophotogrammetry [Weinberg, *et al.* 2006], topography techniques [Ghoddousi, *et al.* 2006] and surface scanning technologies [Hennessy, *et al.* 2002].

In other disciplines such as seating design, design engineers have attempted to design desks and chairs based on anthropometric data [Hibaru *et al.* 1994 ; Parcells *et al.* 1999]. Parcells *et al.* [1999] studied the mismatch between furniture and students' dimensions by measuring anthropometric characteristics of American children aged 11–13 years and the dimensions of their classrooms' desks and chairs, reporting that only 18.9% of students could find an appropriate match. [Gouvali, *et al.* 2005]. Other studies provide detailed anthropometric data and some of them also offer recommendations for design [Klamklaya 2008].

The majority of these studies focus on the acquirement of anthropometric data, and this is limited to physical match, however no studies were found that propose methodologies to define the user group and focus groups for user studies. In particular in the ear industry, there appears to be a gap in the

definition of a reliable user panel and a validated methodological framework to link ear anthropometry to design. Given this background the paper presents two hypothesis:
(1) It is possible to use archetypes to represent large populations and therefore streamline focus groups. A methodological framework should be built based on the notion of archetypes.
(2) It is possible to predict the perception of good fit based on the use of archetypes.

3. Methods

Two studies were carried out to validate the two hypothesis. The first study was executed to generate archetypes from a dataset of 200 participants and the second one was executed to evaluate the data from the archetypes against 20 participants. This section presents the participants and the prototype used in each study in turns together with a description of both studies.

3.1. First Hypothesis – Is it possible to use archetypes to represent large populations?

To test the first hypothesis (H1: Is it possible to use archetypes to represent large populations and therefore streamline focus groups?), a study was executed using an in-the-ear bluetooth headset at an early prototype phase. The actual prototype cannot be presented in this paper due to confidentiality reasons. However, the 3D printed headset resembled in shape and form to the product depicted in Figure 1.

Figure 1. An image of the prototype and respective the critical ear dimensions

Additionally an anthropometric data of ear dimensions was collected to represent the population of Denmark (= 5,500,000 people). The calculation of the sample size was executed with the use of the following mathematical equation.

$$\text{Necessary Sample Size} = (\text{Z-score})^2 * \text{StdDev}*(1-\text{StdDev}) / (\text{margin of error})^2 \quad (1)$$

In the case of Denmark, the sample size required is 196 people for a confidence level of 95%, confidence interval = 7 and population size = 5,500,00 people. Hence, a randomized sample of 200 danish people (100 men, 100 women) was chosen with ages ranging from 22 to 67 years to match the requirements of the calculated sample size. A number of critical ear dimensions were defined and these were measured on both left and right ears of each of the 200 participants (see Figure 2). The linear dimensions (ear length, ear breadth, ear height, concha x and Concha y) were acquired with the use of a vernier caliper. The non-linear dimension (ear circumference) was acquired with the use of an elastic silicon tube that was positioned along the ear circumference curve, as shown in the right image in Figure 3. In total 2,400 linear and non-linear ear measurements were executed.

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	Participants					**Left Ear**					
	Surname	**Name**	**Gender**	**Age**	**Height**	Ear Length	Ear Breadth	Ear Height	ConchaX	ConchaY	Circumference
1	Andersen	Carsten	M	39	189	63,24	33,82	23,41	22,82	18,1	54,24
2			M	28	180	64,67	29,86	17,95	20,16	16,97	54,54
3			M	45	180	65,16	32,87	23,04	19,1	16,68	56,87
4			M	41	190	59,79	26,72	20,28	18,14	18,25	53,11
.			.	.	.	.	.	.	.	.	.
.			.	.	.	.	.	.	.	.	.
.			.	.	.	.	.	.	.	.	.
200			F	32	172	71,44	25,39	11,6	18,1	19,9	49,84

Figure 2. Part of the collected ear data

3.2 Description of the first study

Three critical ear dimensions were chosen out of the six measured based on the areas of physical contact between the prototype and the human ear (see Figure 1). These were the ConchaX, Concha Y and Circumference (Left ear). The data was clustered using the Ward's minimum variance method. The 200 participants were clustered based on the three selected ear dimensions. Hence, the data of ears was clustered in 9 meaningful groups. Figure 3 shows an example of how the clusters were formed (of two out of 9 clusters).

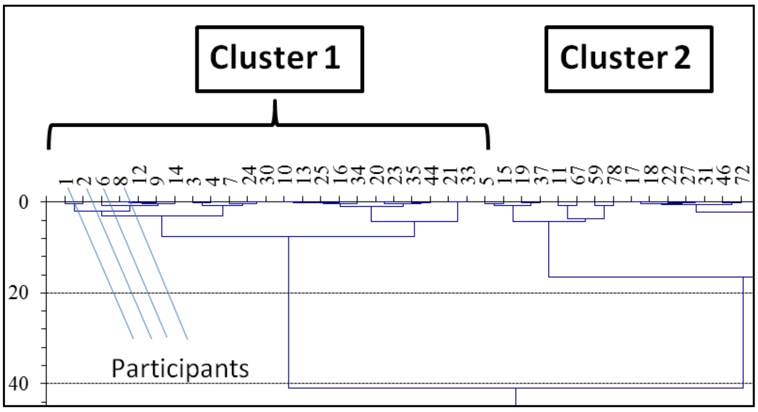

Figure 3. Part of the 9 groups - clusters as derived from Ward's minimum variance method

As shown in Figure 3, each group contained roughly 15 – 25 participants. In the next step frequency diagrams were made for each ear dimension in each group as shown in Figure 4 for Concha X, Group 1. This resulted in 3 frequency diagrams for each of the three ear dimensions within each group.

		Bin Limits		
MIN	12,27	0	12,27	1
MAX	17,61	1	13,03	0
AVG	15,85	2	13,80	0
	0,763	3	14,56	2
		4	15,32	2
		5	16,08	1
		6	16,85	7
		7	17,61	3

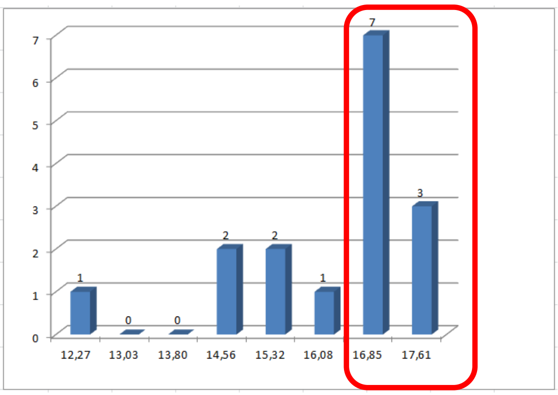

Figure 4. Frequency diagrams for concha X, Group 1

Popular intervals were chosen to include at least 60% of the participants for each group. In the case of Concha X in Figure 5 these intervals were interval 6 and 7. The archetype person was selected based on which person belonged in all three popular intervals for all the three dimensions.

3.3 Second Hypothesis – Is it possible to predict the perception of good fit based on the use of archetypes?

To test the second hypothesis, (H2: Is it possible to predict the perception of good fit based on the use of archetypes?), the same dataset of the 200 participants was used. Among them 20 participants were randomly chosen from all 9 clusters which were generated previously using cluster analysis. These people along with the 9 archetype people who were defined in the previous study participated in an empirical study where they interacted with two groups of three external – ear products. Each of the participants interacted with 3 different external headsets out of a possible 6, see Figure 5. All participants were asked whether they were familiar with the products that were tested in advance, in order to avoid bias towards one or more products. During the interaction the researcher placed the products upon the subjects' ears, hence the users were unable to see the products. The participants were not blindfolded, in order to minimize intrusiveness.

Figure 5. The groups of behind - the - ear and in - the - ear bluetooth headsets

3.4 Data Collection and methodology of the 2nd study

Data for this study was collected with a questionnaire consisting of a question on physical fit. The question was given in a 24 point double sided form. The participants were asked to evaluate the products in terms of good fit, see figure 6.

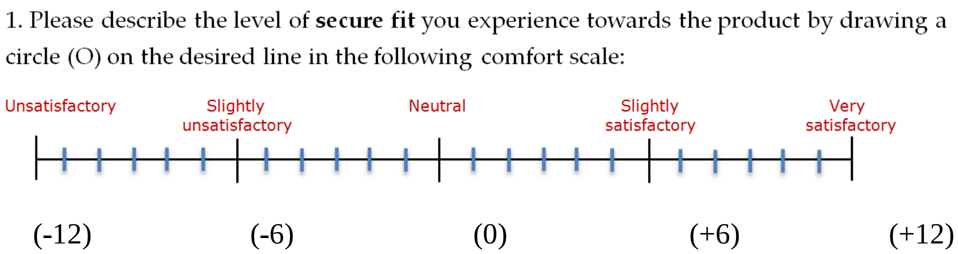

Figure 6. Semantic scale and attributed scores for physical fit

There were a total of 9 archetypes representing 9 clusters. The archetype person's scores were benchmarked against the respective scores of the participants who belonged in the same cluster. Standard deviations were calculated for all the 20 participants against the 9 archetypes to understand if the archetype could represent the cluster (group of participants) from which the archetype belonged.

4. Findings and discussion

4.1 Designing a comfort study to evaluate products based on a reliable user panel

Based on the description of the first study the following methodological framework to create a reliable representative user panel of a large population is proposed, see Figure 7. The method is dependent on the attributes of the product, hence the product definition precedes most phases of the framework to ensure that these are identified early on and used to create the correct clusters and select the appropriate archetype. Once the product is defined it is necessary to execute preliminary interactions involving users. This will provide a reliable set of critical product dimensions that highlight the anthropometric data that needs to be collected. Once the archetypes have been defined these can be used in two ways. The first way is to use the archetype people's dimensions in order to design comfort studies where the researcher could make inquiries on physical properties of comfort towards new prototypes. However, the authors would like to underline the importance of selecting prototypes with similar attributes (e.g. similar manner of use, similar geometry, etc) to the product used at the beginning of the method in order to ensure the validity of the archetypes. The second way is to define test panels based on the generated archetypes. These panels can be used for both quantitative and qualitative studies.

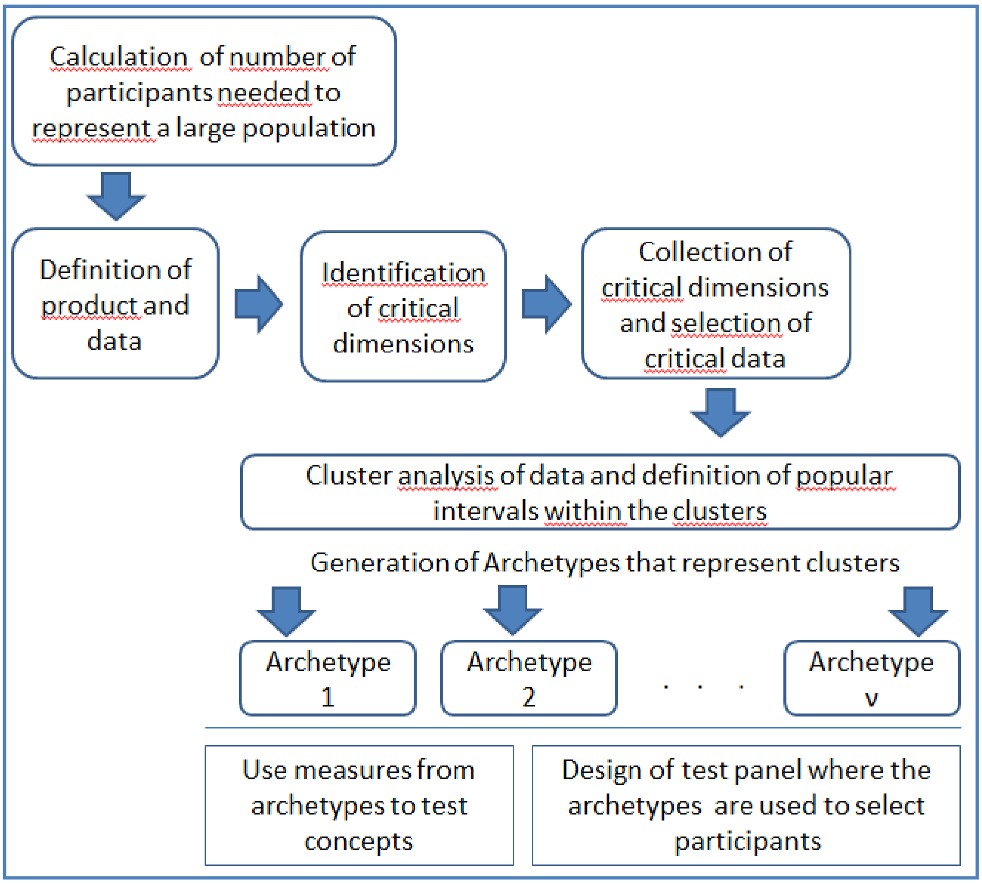

Figure 7. Proposed methodological framework to represent large populations

4.2 Predicting physical comfort based on the notion of archetypes

In this section it is shown that physical factors of comfort can be predicted based on the notion of archetypes. In total, 29 people participated in the questionnaire including the 9 archetype people. The participants scored the fit factor during their interaction with the 3 bluetooth headsets. As shown in Table 1 each of the participants was classified to his or her cluster based upon the ear dimensions. A condition for the validity of the study was that each participant and the archetype from the same cluster interacted with the same group of products. Hence, the responses of the participants could be compared against the responses of the archetype person. Once the responses were retrieved standard deviations of the participants' responses were calculated against their archetypes' responses. This resulted in a number of 60 datapoints.

Table 1. Distribution of participants to the 9 clusters

										Total Number of responses
9 Archetype people	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**9 People x 3 Products = 27 responses**
20 Participants	2	1	3	4	2	1	3	3	1	**20 People x 3 products = 60**

										responses
Product type (In-the ear / Behind-the-ear)	In the ear	Behind the ear	In the ear	Behind the ear	Behind the ear	In the ear	Behind the ear	In the ear	Behind the ear	

As shown in Figure 8, the standard deviations of the 20 participants were plotted against the scores of their archetypes. Not all 60 points can be seen clearly in the graph, due to some overlap of the points due to similar responses. The *zero* x axis is called the line of archetypes and it represents the responses of the archetypes. Each of the 60 points in the graph represents the deviation of the participant of the same cluster response (PartResp) against the archetype response (ArchRes). Hence, each point represents the mathematical difference (ArchRes – PartRes). A close deviation, would mean that the answers of the cluster members were almost similar to the archetypes', indicating that the archetypes can indeed represent their group. If all the points are close to the horizontal axis as possible this would indicate a close match of the participants response to that of the archetype.

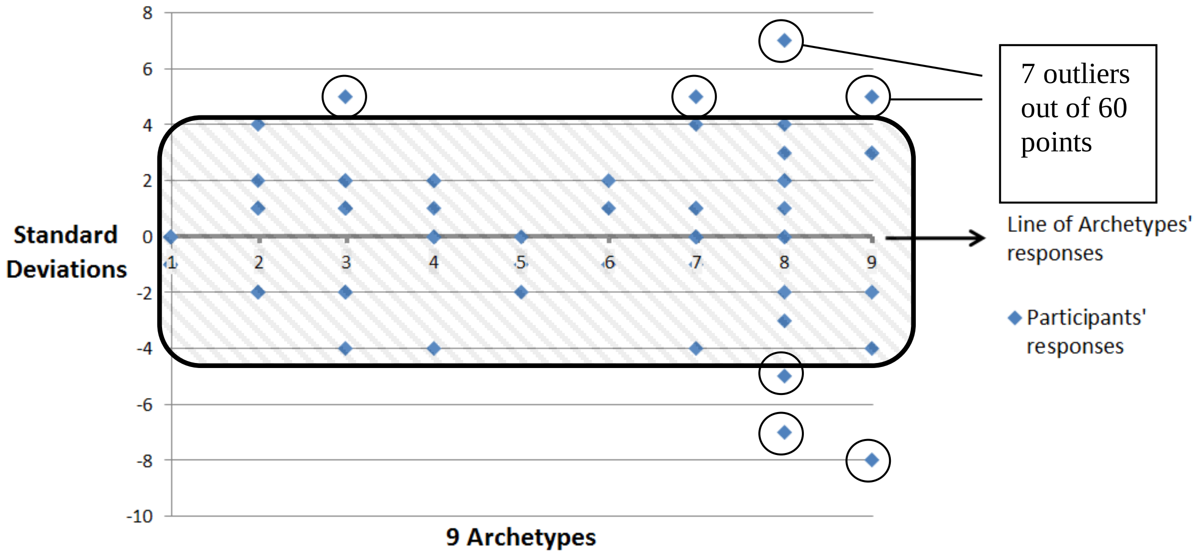

Figure 8. The chart of standard deviations

The scale of the standard deviations on the y axis follows the attributed scores of the 24 - scale question on physical fit which was presented earlier, that is, from -12 to +12. With the exception of 7 (out of a total of 60 responses) close deviations are observed. This translates to the fact that it is possible to predict people's perceptions of physical properties of comfort based on anthropometric data. This finding forms a link between perception and human factors and can be seen in this instance as a prediction of users' perception of fit based on the anthropometric properties of the archetypes that represent them. For the archetypes 7 and 9, where a larger standard deviation is observed the second group of the behind – the – ear products was used for the interaction with the participants. The use of these products may have been the reason for wider deviations since these products have different attributes, compared to the prototype upon which the archetypes were formed. These attributes concern product geometry, the manner of wearing the product, etc. This issue is stressed in the section of the limitations of the study.

4.3 Limitations

Limitations for the two studies are presented in ths section. Ear data of 200 people was collected, this is the minimum number to ensure that the population is sufficiently represented. Including more participants in the data collection will generate more reliable archetypes and will solidify the findings of the second study. Additionally, the selection of more critical ear dimensions would provide with more accurate archetypes. Especially the acquirement of measurements around the ear canal area will improve the predictions of fit since these measurements are linked to the ear gels of the headsets, which is a crucial product component for high scores of physical comfort. A total of 9 archetypes were selected because of limitations in time and resources. There is, however the possibility to create more clusters, which will increase the number of archetypes, hence improve the understanding of the ear data and the prediction of physical comfort. Regarding the second study, although a participant number of 20 is sufficient to demonstrate the method, ideally more than 20 people should have participated so that there is a significant number of participants distributed among the clusters. This is planned in order to gain a better knowledge of the link between perception of physical comfort and anthropometry.Finally the choice of behind-the-ears products may have resulted in wider deviations due to the fact that the behind –the –ear products may require a slightly different set of human factors, that is, a different set of anthropometric ear dimensions.

5. Conclusion

In this paper a methodology to develop a representative user panel for the execution of comfort studies in the ear industry was presented. By using an early prototype as the main case study the the methodological framework was able to be tested and archetypes were generated out of the clusters of the ear data which was collected. The second contribution of this paper links to the validation of the archetypes. By executing the second study of the participants' responses versus the respective responses of the archetypes it was proved that perceived physical comfort can be predicted based on the knowledge of anthropometry and human factors. These findings are of benefit to both designers and researchers by proposing an improved comfort methodology and a meaningful and faster way to design and test the comfort studies executed in the industry. The method adopts the approach of identifying an archetype from clusters analysis on a large set of data, which can then be used to identify participants for a test panel rather than conducting a large number of particpants in user studies. This method contributes in the reduction of cost and time by providing guidance on selecting of participants as an alternative to statistical approach, which would require a large number of users.

References

Bishu, R. R., M. S. Hallbeck, et al., "Seating comfort and its relationship to spinal profile: A pilot study", International Journal of Industrial Ergonomics, Vol. 8(1), 1981, pp 89-101

Chao, A., A. J. Kumar, et al. "An ergonomic evaluation of Cleco pliers.", 'Ergonomics for the New Millennium', 2000, pp 441-442

Cho, 1994, A. Cho, "Fitting the chair to the school child in Korea", Hard Facts About Soft Machines: The Ergonomics of safety, Taylor & Francis, Vol. 24(2), 1994, pp. 279–288

De Looze, M. P., L. F. M. Kuijt-Evers, et al. "Sitting comfort and discomfort and the relationships with objective measures", Ergonomics,Vol. 46(10), 2003, pp 985-997

Ergonomics, Vol. 33 (12),1990, pp 1511–1521

Fellows, G. L. and A. Freivalds, "Ergonomics evaluation of a foam rubber grip for tool handles", Applied Ergonomics, Vol. 22(4), 1991, pp 225-230

Ghoddousi, H., R. Edler, et al., "Comparison of three methods of facial measurement.", International Journal of Oral and Maxillofacial Surgery, Vol. 36(3, 2007), pp 250-258.

Goossens, R.H.M., Teeuw, R. and Snijders, C.J., "Sensitivity for pressure difference on the ischial tuberosity." Ergonomics(submitted), 2002

Habsburg, S. and L. Middendorf, "What really connects in sittin comfort? Em dash studies of correlates of static seat comfort", SAE Prepr (770247), 1977

Hennessy, R. J., A. Kinsella, et al., "3D laser surface scanning and geometric morphometric analysis of craniofacial shape as an index of cerebro-craniofacial morphogenesis: initial application to sexual dimorphism", Biological Psychiatry, Vol. 51(6), 2007, pp 507-514.

Hertzberg, H.T.E. Annotated Bibliography of applied physical anthropology in human engineering, Report No. WADC-TR-56-30, Wright-Patterson Air Force Base. OH: Aero-Medical library, 1958

Hibaru and Watanabe, "A procedure for allocating chairs to school children", Hard facts about soft machines, London, 1994

Jung Hwa S., Hyung-Shik Jung, Surveying the dimensions and characteristics of Korean ears for the ergonomic design of ear-related products, Received 23 May 2001

Jianghong, Z. and T. Long "An evaluation of comfort of a bus seat", Applied Ergonomics, Vol. 25(6), 1994, pp 386-392,

Kee, D. and I. Lee "Relationships between subjective and objective measures in assessing postural stresses", Applied Ergonomics, Vol 43(2), 2012, pp 277-282.

Klamklaya, , Angoon Sungkhaponga, Nantakrit Yodpijitb, Patrick E. Pattersonc, "Anthropometry of the southern Thai population", International Journal of Industrial Ergonomics, Vol. 38(1),2008, pp 111–118

Kleeman, W., "The challenge of Interior design", Boston, MA: CBI, 1981

Kuijt-Evers, L. F. M., L. Groenesteijn, et al., "Identifying factors of comfort in using hand tools", Applied Ergonomics, Vol.35, 2004, pp 453-458

M.K. Gouvali,K. Boudolos, "Match between school furniture dimensions and children's anthropometry", Applied Ergonomics, Vol. 37(6), 2006, pp 765–773

Merllié, M. and Paoli, P. "Working Conditions in the European Union", Dublin: European Foundation for the Improvement of Living and Working Conditions, 2002

Mououdi M.A., Choobineh A.R., "Static anthropometric characteristics of students age range six-11 in Mazandaran province/Iran and school furniture design based on ergonomics principles", Applied ergonomics, Vol. 28 (2), 1997, pp 145–147

Parcells et al., 1999, C. Parcells, M. Stommel, R.P. Hubbard, "Mismatch of classroom furniture and student body dimensions: empirical findings and health implications", Health, Vol. 24 (4), 1999, pp. 265–273

Paul, R. D., "Nurturing and pampering paradigm for office ergonomics", Proceedings of the Human Factors and Ergonomics Society 1, 1997, pp 519-523

Richards, L. G. "On the psychology of passenger comfort", Human Factors in Transport Research, Vol. 2: User Factors: Comfort, The Environment and Behaviour, 1980, pp 15-23

Sanders and McCormick," Human Factors in Engineering and Design", (seventh ed), M.S. Sanders and E.J. McCormick, McGraw-Hill, New York, 1993

Slater K. "Human Comfort (Book)." Contemporary Sociology 16(6), 1987

The Oxford Dictionary of English (2nd ed., rev. 2005)

Vink, P. and S. Hallbeck, 2012, "Comfort and discomfort studies demonstrate the need for a new model." Applied Ergonomics, Vol. 43 (2), pp 271-276

Vink, P., "Comfort and design: principles and good practice", Boca Raton CRC Pres, 2005

Vink, P., Hark, T.A. and Krause, F., "Future Demands on Comfort in Construction Vehicles' Interiors", 2001, according to Manufacturers, Hoofddorp: TNO Work and Employment

Weinberg, Naidoo, Govier, Martin, Kane, Marazita, "Anthropometric Precision and Accuracy of Digital Three-Dimensional Photogrammetry", Journal of Craniofacial Surgery, Vol. 17(3), 2006, pp 477-483

Wilder, D., M. L. Magnusson, et al., "The effect of posture and seat suspension design on discomfort and back muscle fatigue during simulated truck driving", Applied Ergonomics, Vol. 25(2), 1994, pp 66-76

Zhang, L., M. G. Helander, et al., "Identifying factors of comfort and discomfort in sitting", Human Factors, Vol. 38(3), 1996, pp 377-389

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